quantum circle

White paper

Let's engage on Quantum technology

Prepare Belgium for the Quantum decade

quantumcircle.be

The Quantum technology momentum
Time to act is now!

Quantum-based applications have the potential to revolutionize many industries, such as pharma, chemistry, health, energy, finance, mobility, aerospace and telecom.
The impact on our Belgian economy can be significant if we decide to act now. However, Quantum technology also entails significant challenges and risks, such as cybersecurity, ethical, legal, and societal implications, as well as technical and operational hurdles.

Quantum technology is a cutting-edge and multidisciplinary field that harnesses the power of Quantum physics to bring our country endless novel and transformative applications in the fields of computing, communication and sensing.

We are a collective of multi-disciplinary Quantum enthusiasts from various industries and backgrounds, united by a common vision: engage with our Belgian society on the urging need for a proactive and collaborative approach to Quantum technology.

The European Union and many member states already show the way. Along with over 10 European countries, the EU has a clear and ambitious research and development strategy for Quantum technology. Our neighbouring countries are already actively building and nurturing strong and vibrant ecosystems in this domain. The EU launched a Quantum technologies flagship program along with generous investments, aimed at supporting the endeavours of Quantum researchers for a decade. We are not alone in seeing the time to act and calling for action! Governments and regulators around the world are recognizing the urgency and importance of Quantum technology.

Belgium is a blind spot on the European Quantum map. Quantum technology is being pursued and developed across many Belgian universities and multiple research institutes. Also, some large corporations are exploring its possibilities and benefits. However, the Belgian startup scene is actually missing out on the opportunity of innovation that Quantum technology can bring. As a community, we identified more than 120 applicable Quantum-based use cases which already can be explored today.

Quantum technology embedded in everyday life

Quantum technology is a game-changer that will fuel our Belgian economy and society endless **innovative applications in communication, computation, sensing, and metrology**.

Most early adopters and researchers concur that Quantum technology will offer unprecedented advantages and solutions for four major domains, namely: **cryptography, simulation, optimization, and machine learning**. These domains cover a wide range of potential use cases which can benefit from the enhanced performance and capabilities of Quantum technology. While the future is uncertain and unpredictable, some of the envisioned applications of Quantum technology are already emerging and very promising.

Introducing Quantum technology in brief

Quantum technology exploits the laws of Quantum physics to perform intricate computations at **speeds beyond the reach of classical computers**. This groundbreaking technology promises to **bring energy-efficiency** compared to today's greedy classical computers, with the ability to **tackle intractable problems** we simply can't solve today. Quantum has the potential to **profoundly influence most Industries**, from improving resource allocation in public services to strengthening cryptography for secure communication in government operations.

Most promising areas for Quantum innovation

- **Encryption** and decryption could safeguard our confidential data and preserve the security of our digital transactions from Government & Corporate intrusion.

- **Simulation** will accelerate the development of new drugs, chemical or physics research, materials science, or the valuation of financial derivatives.

- **Optimization** can improve the forecasting of weather patterns and climate changes, enabling us to mitigate the impact of natural disasters and pursue sustainable development, find optimal allocation of resources, and solve a variety of minimum and maximum finding problems.

- **Machine Learning** shall enhance the speed and accuracy of fraud and money-laundering detection, the advancement of automated vehicles, and the performance of AI algorithms in areas of classification, regression, and clustering. We also see synergies between Generative AI and Quantum computing.

Quantum technology spans three main subfields: computing, communication and sensing

Quantum computers differ from classical computers mainly in their fundamental logic of computation. Classical computers, the usual devices we use today, process information using bits that can only be in one of two states, either 0 or 1. These bits form the basis of binary code, and classical computers perform calculations by manipulating sequences of these binary digits. On the other hand, Quantum computers operate on the principles of Quantum physics. They use Quantum bits, or qubits, which can be in multiple states at the same time, a phenomenon known as superposition. The so-called state of superposition, combined with entanglement or the instant state modification of several linked qubits, are unique properties that allow Quantum computers to process a huge amount of information more effectively than classical bits.

Quantum communications will enable a secure Quantum Internet. Classical cryptographic schemes protect data from classical computers but are exposed to Quantum computers. To prepare for this threat, Europe is launching a Quantum communication infrastructure. All 27 member states have signed a declaration, pledging to cooperate in exploring the development of a Quantum Communication Infrastructure (QCI) across Europe. This initiative aims to boost European capabilities in Quantum technologies, cybersecurity, and industrial competitiveness. Quantum communications use Quantum technologies to guarantee secure communication. This approach relies on three fundamental pillars: Post-Quantum Cryptography (PQC), Quantum Random Number Generators (QRNGs) and Quantum Key Distribution (QKD).

- **Post-Quantum cryptography (PQC)** is a branch of cryptography that develops and studies algorithms that are resistant to attacks by Quantum computers. These algorithms are based on mathematical problems that are hard to solve. PQC aims to protect the security of current and future data and communication from Quantum threats, especially in domains that require long-term security, such as government, defense, or finance.
- **Quantum random number generators (QRNGs)** are devices that can produce truly random numbers, ensuring the generation of highly secure keys for classical data encryption and decryption protocols, immune to potential guessing by attackers.
- **Quantum networks, including Quantum key distribution (QKD)** is a method of creating and sharing secret keys between two parties using the principles of Quantum physics. These keys can then be used to encrypt and decrypt messages securely. QKD relies on the fact that any attempt to observe or interfere with a Quantum system, such as a photon, will change its state and leave a trace. By sending Quantum signals, such as polarized photons, over a dedicated channel, the two parties can detect any eavesdropping and generate a random key that is known only to them. QKD is different from Quantum cryptography, which uses complex algorithms to secure the data Itself.

Quantum sensing has significant advantages over classic sensors as facilitators for advanced Internet of Thing (IoT) applications. By using Quantum properties such as superposition, Quantum sensors can overcome the constraints of classical sensors in detecting and measuring various physical quantities, such as magnetic fields, gravity, and time. Quantum sensing offers potential for enhancing fields such as navigation, environmental monitoring, spectroscopy, and fundamental scientific research.

Quantum technology, covering the three domains of computing, communication, and sensing, is ready to transform many of our Belgian industries by enabling advanced calculations, secure data transfer, and highly precise measurements.

Use-cases as driver for future applications

Quantum computers are still in their infancy, and forecasting their economic impact and precise uses is a daunting task. However, our community endeavored to create **a first overview, showcasing more than 120 potential solutions**, revealing the transformative applications of Quantum technology across a range of industries. The earliest anticipated use cases involve simulation for energy, mobility, finance, material science, healthcare, and post-Quantum cryptography. In a later stage, we expect the emergence of more use cases centered on optimization and machine learning services.

Promising Quantum technology applications to fuel our economy

- **Life Sciences**: biological target discovery, compound lead generation and optimization, drug target interactions, disease detection and clinical trial improvement.
- **Chemicals**: modelling and optimization of chemical reactions, battery production, molecular simulation and exploration.
- **Finance**: risk management, dynamic portfolio optimization, derivatives valuation, fraud prevention.
- **Automotive**: traffic flow optimization, car design improvement, crash simulation, new materials for clean powertrains, fuel cells optimization, industrial efficiency and supply chain improvement.
- **Aerospace**: air traffic optimization, airplane design improvement, fleet optimization, cargo loading improvement and better airport gate scheduling.
- **Advanced IoT** applications: high-precision GPS navigation, prediction of volcanic activity and CO2 emission measurement, neural sensing and medical imaging.

Public & private collaboration towards Quantum exploration

To put Belgium on the map for EU and cross-border innovation discovery, **we continuously Interact with over 250 public and private, Belgian & international contacts**, perform regular market analysis and assessment of our country's Quantum maturity.

Our governments can drive initiatives with economic and societal impact

- **We are vocal towards federal and local authorities** in support of plans to incorporate Quantum research and development related directives into their digital strategies.
- **We welcome the appointment of a working group** responsible for developing federating policies to align country-wide Quantum initiatives on local and federal level.
- **We do require transparency on funding mechanisms** for those involved in the Belgian Quantum ecosystem with transparent access to enabling public stakeholders and funding.

We announce the creation of a vibrant Belgian Quantum ecosystem

- **We invite governments to engage with local ecosystems**. On our side, we will facilitate collaboration between academics, research, technology providers, public and private sectors. We will also reach out to European and global Quantum ecosystem initiatives.
- **We will prepare organizations for the Quantum decade** by (1) identifying specific business problems where Quantum might be the answer, (2) matching proven use cases with these challenges and (3) facilitate interactions with our universities, researchers, technology providers and international contacts.
- **We will actively screen the market for Quantum talents** to help organizations find skilled individuals via webinars, seminars and conferences. In a later stage we envision to organize hackathons and bootcamps.

Quantum Circle, the first Quantum community for Belgium

Our sense of purpose

We unite Quantum explorers and experts to champion revolutionary technology, collaborate on ground-breaking applications, and drive market adoption, shaping a visionary investment landscape for societal and economic impact.

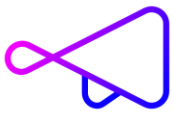
Intrigued? This is what we stand for:

- **We gather all stakeholders** in Quantum computing, communication and sensing under one roof.
- **We advocate the game-changing potential** of Quantum technologies, collaborate on innovative use cases, cultivate expertise and ignite rapid market adoption.
- **We want to establish the foundation for a visionary investment climate** that will leave a lasting impact on the technological landscape.

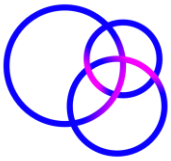
Ease Quantum adoption. This is how we do it:

- **We develop a vibrant Quantum ecosystem** and build a sustainable supply chain.
- **We facilitate collaboration** between academics, research, technology providers, public and private sectors.
- **We identify high-impact Quantum applications** in all relevant domains.
- **We empower the Quantum generation** through talent search and education.
- **We connect to European and global innovation hubs** to bridge the tech divide.

Quantum Circle offerings. Our proposition in a nutshell:



Communication:
grant access to regular online webinars and live meetups on topics relevant to all community stakeholders. We communicate through our social channels, a member website, via online webinars and live meetups. And we will publish white papers like the one you're holding right now.



Connection:
share vision and experience with peers, be on top of the latest academic research and connect with global technology providers. We connect members via insights sharing, experience exchange and interactions across stakeholders. Also, we provide guidance on technology transfer and organize live conferences.

Collaboration:
engage to co-create industry-specific or cross-sector use cases facilitated by our multi-disciplinary circle experts. We collaborate on industry-specific research & development and exchange cross-sector use cases. Our experts will provide facilitation services and we will subscribe to cross-border conferences.

Let's talk about Quantum

For further information, please **visit our website** quantumcircle.be

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